FoleyAutomatic

Physically-based Sound Effects for Interactive Simulation and Animation

Kees van den Doel, Paul G. Kry, and Dinesh K. Pai
University of British Columbia

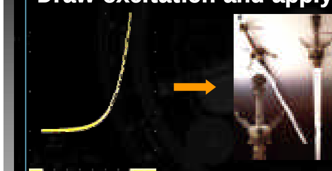
Non-speech & Non-music = Foley

Contact sounds important:

Simulation Based Sound-effects

Hand-crafted Sound-effects

Draw excitation and apply to sword model



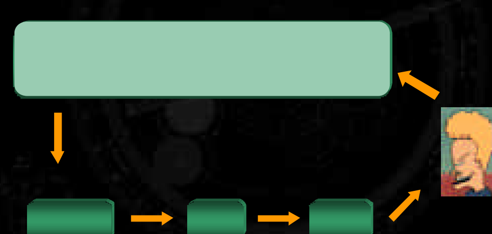
Speed/force profile

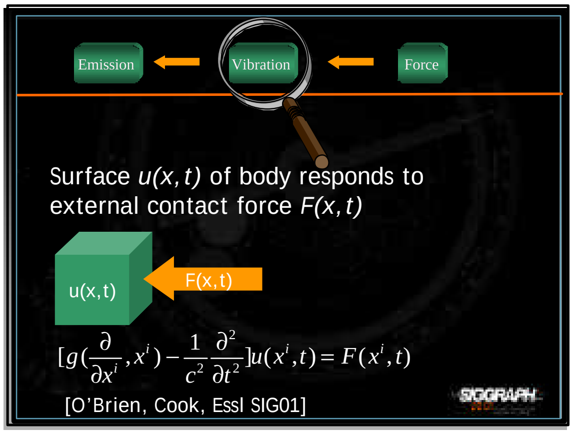
- Sword 1
- Sword 2
- Damped
- Ribbed
- Stick
- Bell

FoleyAutomatic Features

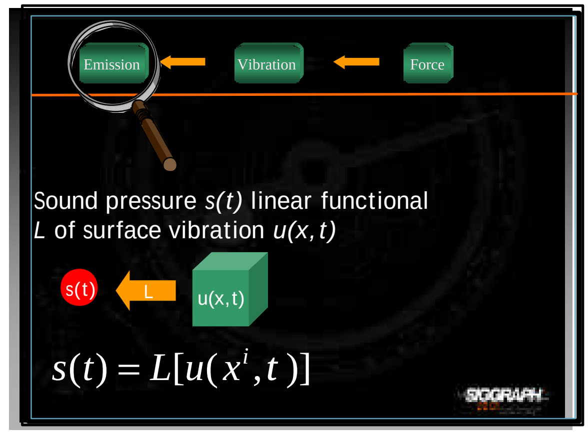
- Modal resonance models of solids [Cook 96, van den Doel & Pai 96]
- Location dependent sounds [van den Doel & Pai 98]
- Impact, slide, roll excitation models
- Real-time, low latency
- Model parameters measurable
- Easy integration with simulation/animation
- Practical (easy to deploy/author models)

Synthesis Method

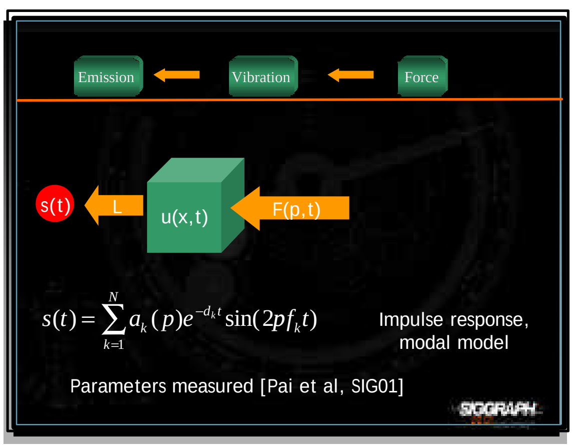




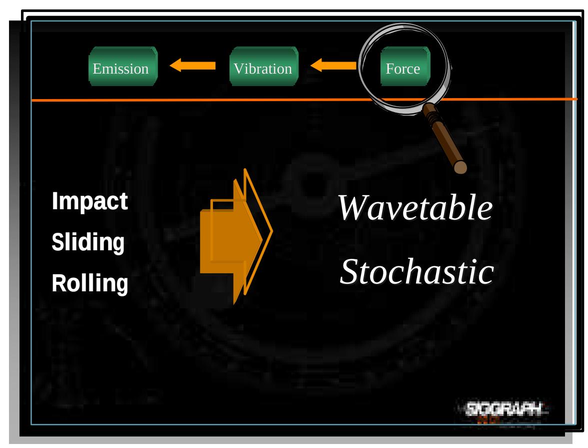
Emission
Vibration
Force
Surface $u(x,t)$ of body responds to external contact force $F(x,t)$
u(x,t)
F(x,t)
$[g(\frac{\partial}{\partial x^i}, x^i) - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}]u(x^i,t) = F(x^i,t)$
[O'Brien, Cook, Essl SIG01]
SIGGRAPH



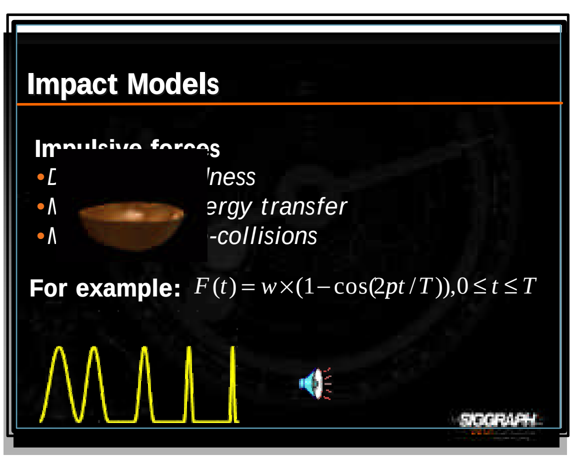
Emission
Vibration
Force
Sound pressure $s(t)$ linear functional L of surface vibration $u(x,t)$
s(t)
L
u(x,t)
$s(t) = L[u(x^i, t)]$
SIGGRAPH



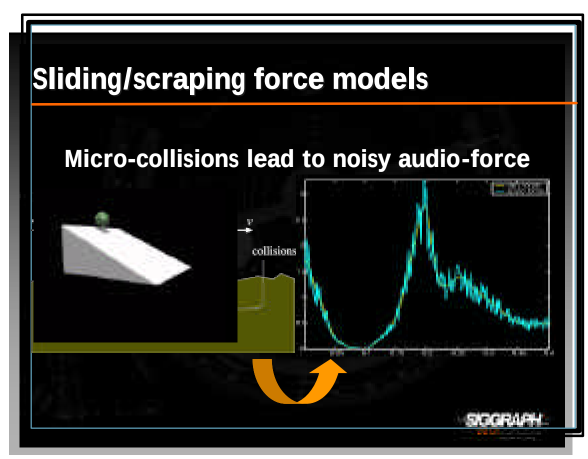
Emission
Vibration
Force
s(t)
L
u(x,t)
F(p,t)
$s(t) = \sum_{k=1}^{N} a_k(p) e^{-d_k t} \sin(2pf_k t)$
Impulse response, modal model
Parameters measured [Pai et al, SIG01]
SIGGRAPH



Emission
Vibration
Force
Impact
Sliding
Rolling
Wavetable
Stochastic
SIGGRAPH



Impact Models
Impulsive forces
•D 'ness
•M ergy transfer
•M -collisions
For example: $F(t) = w \times (1 - \cos(2pt/T)), 0 \le t \le T$
SIGGRAPH



Sliding/scraping force models
Micro-collisions lead to noisy audio-force
v
collisions
SIGGRAPH

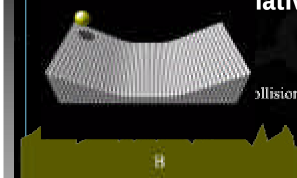
Sliding/scraping force models

Wavetable approach:
- Store force profile table
- Modulate amplitude with energy transfer
- Modulate rate with contact speed

Synthesis approach:
- Fractal noise represents roughness
- Filter through reson filter
- Resonance ~ contact speed
- Width ~ randomness of surface

SIGGRAPH

Rolling force models



lative surface motion

Differences with sliding:
- Smoother: Use low pass
- More damping
- Harder to create
- Less understood
- Essential coupling?
- [Hermes 98, Stoelinga 01]

SIGGRAPH

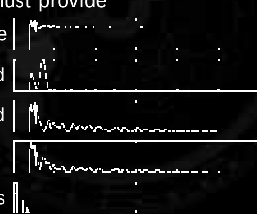
Implementation: Audio Synthesis

Audio synthesis
- Java Audio Synthesis System (JASS)
  - [van den Doel & Pai 01]
  - www.cs.ubc.ca/~kvdoel/jass (try it at home)
- 0.1% CPU per mode on Ghz Pentium III
- Real-time or offline
- Low latency

SIGGRAPH

Dynamic Simulation for Sound

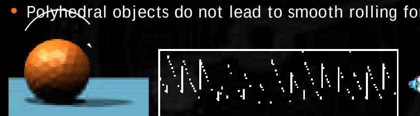
- Can be used with most multi-body techniques
- Simulation must provide



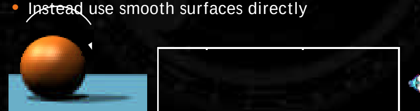
SIGGRAPH

Smooth Surfaces

- Polyhedral objects do not lead to smooth rolling forces

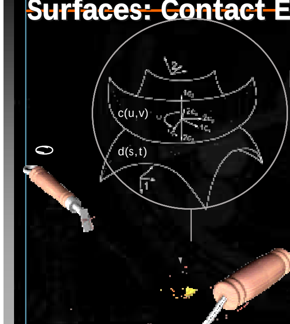


- Instead use smooth surfaces directly



SIGGRAPH

Contact Dynamics for Smooth Surfaces: Contact Evolution



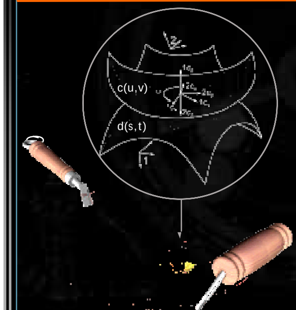
Evolve the contact in Reduced coordinates

$q = (u,v,s,t,\psi)$

$\ddot{q} \rightarrow \dot{q} \rightarrow q$

SIGGRAPH

Contact Dynamics for Smooth Surfaces: Contact Evolution



- Piecewise parametric surfaces, subdivision surfaces
- Explicit integration, no stabilization
- Multiple contacts and conforming contacts require different coordinates or other methods

Demo

- Loop subdivision surfaces
- Sphere tree for collision detection
- Chatterjee Ruina collision response
- Interaction with PHANTOM
- Sound with JASS

Conclusions

FA is practical system for contact sounds

- Modal resonance models for objects
- Measured or stochastic excitation models
- Driven by simulation parameters
- High quality
- Efficient
- --- The End ---

Sound quality

Reasons for inaccuracy:

- Absence of highly damped modes
- Real surfaces more complex than modeled
- Intermodal interactions during sliding/rolling
- Non-linear effects
- Contact events more complex than modeled